1. Introduction

1.1 Purpose of the Economic Appendix

The purpose of this appendix is to measure the economic and social effects of the alternatives proposed under the Lower Snake River Juvenile Salmon Migration Feasibility Study. Section 102 of the National Environmental Policy Act (NEPA) and Council on Environmental Quality (CEQ) guidelines, which interpret NEPA, require that economic and social effects be identified. Evaluation of these effects is critical to decision makers and also important to others interested in the outcome of this feasibility study. The evaluation presented in this document uses economic measures to evaluate efficiency changes in the nation's production of goods and services. This evaluation is designed to identify the gains and losses to society as a whole. The effects that the proposed alternatives would have upon the region and specific groups of individuals are also examined. The overall structure of this analysis is discussed in more detail in Section 1.3 below.

The economic and social effects of each proposed alternative are evaluated for the primary uses of the lower Snake River, which include electric power generation, recreation, transportation, and water supply. Economic effects are typically stated in monetary terms. In some cases, where monetary measures are not available, qualitative assessments are used.

1.2 Study Area

The geographic scope of the economic analysis conducted for the FR/EIS is consistent with the analysis of the physical effects of the proposed alternatives. The actions proposed under the selected alternative would be implemented, as appropriate, at each of the four run-of-river dams along the lower Snake River. In general, the economic effects were evaluated wherever significant physical effects were identified. In the case of the transportation analysis, for example, the study area includes grain-producing areas, as well as river origins and destinations for other commodity groups that are transported via the lower Snake River. The social analysis is, however, primarily limited to a series of focus communities intended to provide decision makers with information concerning potential impacts across a range of different communities. A regional base map that shows the location of the four lower Snake River dams and the surrounding region is presented in the foreword to this appendix.

1.3 Structure of Analysis

The structure of the economic and social analysis developed for this FR/EIS is based upon the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* developed by the U.S. Water Resources Council (WRC) (WRC, 1983). These guidelines recommend that the evaluation and display of the effects of proposed alternatives be organized into four accounts:

- The national economic development (NED) account, which displays changes in the economic value of the national output of goods and services
- The environmental quality (EQ) account, which displays nonmonetary effects on significant natural and cultural resources

- The regional economic development (RED) account, which addresses changes in the distribution of regional economic activity
- The other social effects (OSE) account, which addresses potential effects from relevant perspectives that are not reflected in the other three accounts

The NED account is the only account required under the WRC guidelines. The guidelines recommend that other information that is required by law or that will have a material bearing on the decision-making process should be included in one of the other accounts (EQ, RED, or OSE) or in some other appropriate format. The four accounts and their relationship to this analysis are discussed in the following sections.[1]

1.3.1 National Economic Development (NED)

The NED account addresses the net effects of a proposed action upon the nation. NED analysis is concerned only with economic efficiency at the national level. Economic gains achieved by one region at the expense of another region are not measured as NED benefits. This is because the Federal objective in water resources planning is national economic development. If a Federal project induces a firm to leave one region for another, the increase in regional income for the host region may well be a benefit to that area. However, from a national perspective, if the impacts to the new host region are included as a benefit, then the loss of income to the former host region must be included as a project cost. In most cases, this type of gain to one region is another region's loss, and the two effects represent a transfer of income that cancels out any net change. As a result, NED analysis does not consider these types of transfers. Regional impacts are instead addressed under the RED account, which is discussed in Section 1.3.3 below.

Beneficial effects measured under the NED account include increases in the economic value of the national output of goods and services, the value of output resulting from external economies caused by the proposed alternative, and the value associated with the use of otherwise unemployed or under-employed labor resources. External economies may be defined as benefits generated outside of a market transaction. Individuals may benefit from these types of external economies without having to reimburse the party responsible for the positive effect.

Adverse NED effects are usually the opportunity costs of resources used in implementing a plan. All resources are scarce, and we must choose when to use them. Choose more of one thing, and we simultaneously choose less of another. If we make the best choice from a number of alternative uses of a river reach, at a minimum it costs us the opportunity to do the next best thing with the reach. The NED account distinguishes among implementation outlays, associated costs, and other direct costs. Implementation outlays are the financial outlays, including operation, maintenance, and replacement costs, incurred for implementation of the plan. Associated costs are those required in addition to implementation outlays. These are typically costs for measures needed to achieve project benefits. Other direct costs represent the uncompensated and unmitigated costs of resources that are affected by the project or plan.

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[1] This discussion of the four accounts is drawn from the WRC guidelines (WRC, 1983) and supplemented by additional material from the *National Economic Development Procedures Manual—Overview Manual for Conducting National Economic Development Analysis* (IWR Report 91-R-11). The interested reader is referred to these documents for additional information.

The general measurement standard for the value of goods and services is defined as the willingness of users to pay for each increment of output associated with a proposed alternative. Since it is not usually possible to obtain willingness to pay values, alternative or proxy measures are used. These measures include actual or simulated market price, change in net income, cost of the most likely alternative (e.g., replacement cost of hydropower), and administratively established values.

The NED analysis presented here addresses power, recreation, transportation, water supply, anadromous fish, tribal circumstances, flood control, and implementation/avoided costs. A net gain in recreation use under Alternative 4, Dam Breaching, is an example of an NED benefit in this case. Beneficial NED effects are also associated with increased commercial fishing under this alternative. The loss of hydropower and the associated increase in the cost of generating electricity are examples of NED costs associated with Alternative 4, Dam Breaching. Another example of an NED cost associated with the dam breaching alternative is the net increase in transportation costs for commodities that are presently shipped on the lower Snake River.

The application of the NED analysis to each resource area is presented in Section 3.0 of this appendix.

1.3.2 Environmental Quality (EQ)

The EQ account provides a means of displaying and integrating qualitative information on the effects of proposed alternatives on significant resources and attributes of the human environment (WRC, 1983). Beneficial and adverse effects in the EQ account address changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources.

The Tribal Circumstances and Perspectives report developed for this analysis by Meyer Resources, Inc. in association with the Columbia River Inter Tribal Fisheries Commission (CRITFC) suggests that tribal circumstances and effects should be incorporated into the economic assessment under the EQ account. While tribal assessments carried out by Federal agencies tend to concentrate on historic cultural resources, primarily sites and artifacts, the Tribal Circumstances and Perspectives report indicates that existing tribal communities and groups should also be considered under the definition of cultural resources.

The Tribal Circumstances and Perspectives report also suggests that the tribal effects analysis contains some information identified by the WRC guidelines as part of the OSE account—particularly with regard to the issues of Tribal health and displacement. Tribal circumstances are discussed qualitatively in Section 5.0 of this appendix. Tribal circumstances are also briefly addressed in the context of the NED analysis in Section 3.6.

1.3.3 Regional Economic Development (RED)

The RED account addresses the changes in regional economic activity that would result from each alternative. Two measures typically used in RED analysis to assess the effects on regional economies are income and employment. The regional analysis presented in this document addresses changes in income and employment. It also includes a third measure—business sales volume. The regions typically used for RED analysis are those that would experience particularly significant project-related income and employment effects.

The regional analysis presented in this document measures regional effects using input-output models. This analysis, developed by the DREW Regional Analysis Workgroup, is primarily based

on estimates of direct economic effects generated by other DREW workgroups as part of the NED analysis. Most effects associated with the proposed alternatives would occur in the lower Snake River region. This region is the primary focus of the regional analysis. Four input-output models were developed to assess the regional impacts of these effects. County data were aggregated into a 25-county study area that was further divided into three subregions. The counties that comprise the subregions and the combined lower Snake River study area are shown in Figure 1-1. The subregion models are applied in cases where impacts are localized. Examples of localized impacts include possible reductions in agriculture irrigated from Ice Harbor reservoir under Alternative 4, Dam Breaching. Changes in sportfishing and recreation trips to the lower Snake River are another example of localized impacts.

Models were also developed for the states of Washington, Idaho, Oregon, and Montana. These state models are used to assess impacts that would impact several states. State-level impacts assessed with these models are those associated with possible increases in electricity rates under Alternative 4, Dam Breaching.

In addition to potential project impacts that would occur in the lower Snake River region and possible increases in electricity rates that would likely affect a number of states, there would also be regional impacts associated with changed harvests of anadromous fish. These impacts were assessed for changes in both commercial and recreational harvests. This analysis conducted by the DREW Anadromous Fish Workgroup used input-output models constructed for the Pacific Northwest coastal counties.

The regional analysis is presented as Section 6.0 of this appendix.

1.3.4 Other Social Effects

The OSE account addresses potential effects from perspectives that are relevant to the evaluation process, but are not reflected in the other three accounts. Categories typically addressed as part of this account include community impacts; life, health, and safety factors; displacement; and long-term productivity. The social analysis presented in Section 7.0 of this appendix addresses some of the likely social impacts on selected local communities. The proposed alternatives would affect communities differently. One community may lose business and suffer an increase in unemployment and decreases in income and tax revenue, while other communities may benefit through increased investment or expenditures. The social analysis draws on the findings from the NED and RED analyses and primarily addresses 9 focus communities. These communities are highlighted on Figure 1-1.

Tribal communities are not addressed in the Social Analysis conducted by the Drawdown Regional Economic Workgroup (DREW) Social Analysis Workgroup, but are addressed separately in the Tribal Circumstances and Perspectives report developed by Meyer Resources, Inc., in association with CRITFC. The findings of this report are summarized in Section 5.0 of this appendix.

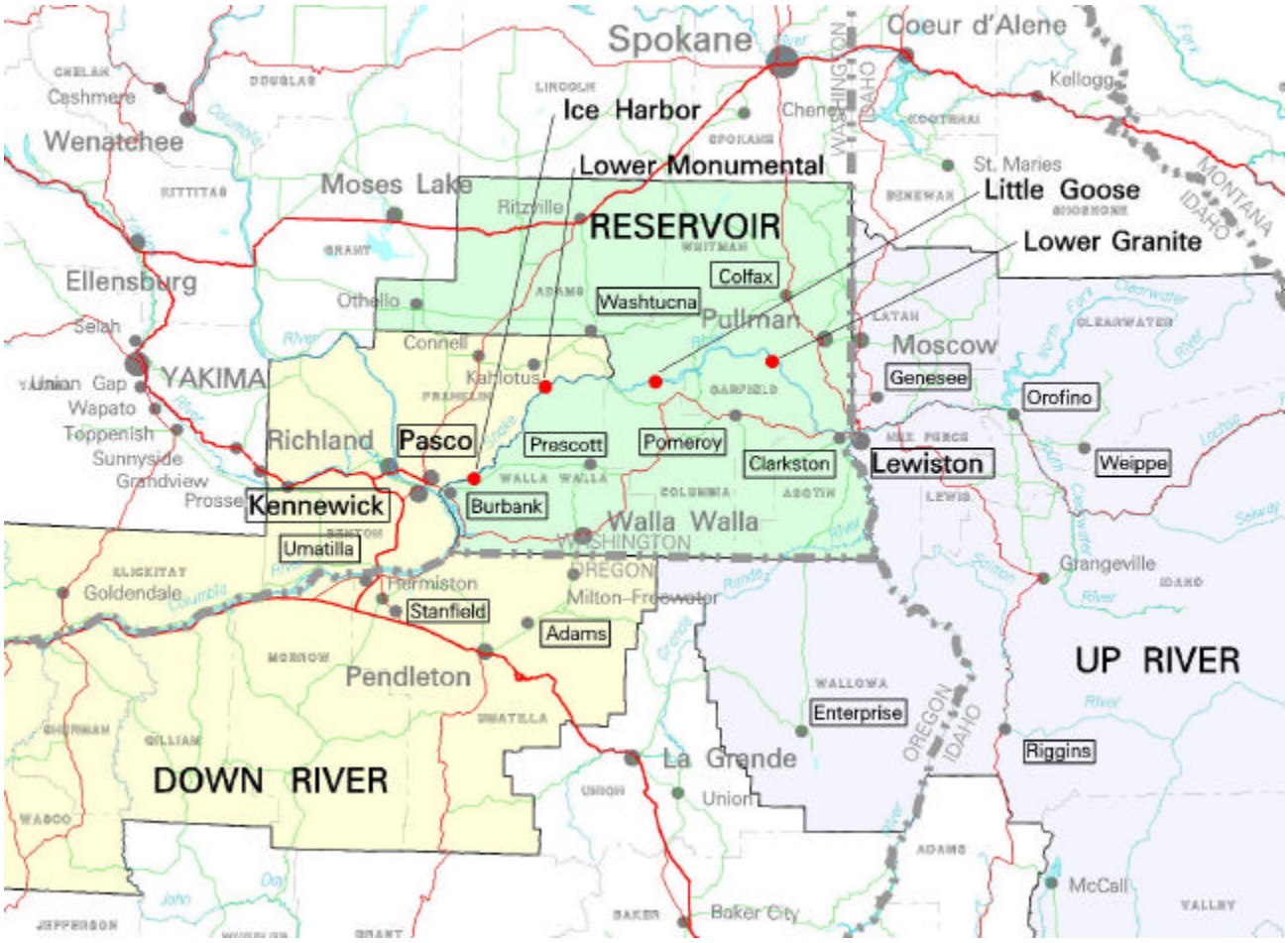

Figure 1-1. Subregions and Focus Communities

1.4 Drawdown Regional Economic Workgroup

The economic effects of actions related to the lower Snake River have been analyzed by numerous entities throughout the region. To reduce conflicting analyses and pool resources for a more efficient effort, the Corps convened the Drawdown Regional Economic Workgroup (DREW) to develop a combined economic analysis. Members of DREW include representatives of the Corps, Bonneville Power Administration (BPA), Bureau of Reclamation (BOR), National Marine Fisheries Service (NMFS), U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (USFWS), Northwest Power Planning Council (NPPC), CRITFC, and other interested groups. DREW meetings, held at various locations throughout the region on a roughly bi-monthly basis, were regularly advertised and open to the public. Members of the public regularly participated in and contributed to these meetings.

DREW conducted the necessary technical analyses to assess the economic impacts associated with each of the various alternatives. Within DREW, smaller workgroups oversaw and provided technical support for each area of analysis. The Technical Report on Hydropower Costs and Benefits was, for example, developed by the DREW Hydropower Impact Team. Study design and technical analysis was, as a result, a collaborative process that aimed to encompass a range of viewpoints and technical skills. Work products produced by DREW were reviewed by the NPPC's

Independent Economic Advisory Board (IEAB), a review board of economists drawn from academia and private industry. IEAB provided independent peer review of work products and advice in resolving technical issues, as necessary.

The key areas of analysis evaluated by DREW were closely related to one another. Results from one workgroup were often required inputs to another. Technical reports were developed for each area of analysis. The analysis presented in this appendix is based on the findings of these reports, which are referenced, as appropriate.

1.5 Study Assumptions

1.5.1 Period of Analysis and Price Level

DREW determined that a 100-year period of analysis would be used to assess all project impacts. This long-term perspective reduces the likelihood that the comparison of alternatives will be influenced by short-term fluctuations in trends or market conditions.

The base year for this analysis is fiscal year (FY) 1998, but the implementation year is FY 2005. FY 2005 was selected because it is assumed to be the earliest "in-service" date (assuming that the implementation process begins on January 1, 2001). The 100-year period of analysis extends from the implementation year, FY 2005, through 2104. Benefits and costs incurred during the period of analysis are discounted to the beginning of this period (FY 2005) using the selected interest rates (see below). Implementation expenditures and other economic costs and benefits that would occur prior to FY 2005 are brought forward to that date by charging compound interest at the project discount rate from the date that the costs and benefits occur. These costs and benefits are then converted into 1998 dollars and annualized to provide an average annual value for each alternative.

Due to the uncertainty associated with projecting socioeconomic parameters, projections of certain parameters, such as population, income, fuel prices, power loads, and commodities that would be transported on the lower Snake River are limited to a 20-year period from 1998 though 2018. From that point on, constant levels are assumed to the end of the 100-year period of analysis. These parameters are identified in the text, as appropriate.

1.5.2 Discount Rate

For most water-related projects, the bulk of project costs tend to be incurred during project implementation. Benefits, on the other hand, typically are realized as uneven flows of income or monetary benefits over a much longer time. Although both costs and benefits are measured in dollars, the dollars spent on implementation today cannot be directly compared to the dollars that will be realized years from now. One million dollars today, for example, is not the same as $1 million 20 years from now. The $1 million today could be put in the bank where it would earn 10 percent interest annually; in 20 years it would be worth $6.7 million. If, for example, a choice existed between building a $1 million project that would yield a $1 million benefit in 20 years or saving the money at 10 percent, clearly saving would be the best option from a purely economic perspective.

To account for differences in the time value of money, future benefits and costs of all components of the DREW analysis are discounted to a common date by using appropriate interest rates. This reduces the stream of benefits and costs that occur over the 100-year study period to a single value for each alternative. These present-worth values are then converted to an average annual values.

This practice is intended to allow reasonable cost comparisons among alternatives that have benefits and costs occurring at different times.

Selecting an appropriate discount rate for this type of economic analysis is often a source of controversy because it influences the attractiveness of allocating resources between the present and the future. Economic theory suggests that the discount rate used for project analysis should reflect the return that can be earned on resources employed in alternative private use. As a result, market interest rates tend to figure prominently in allocating investment funds among alternative uses. Market interest rates reflect the typical rates of real return on investments in the private economy and are instrumental in determining the values of real assets such as farmland, buildings, and equipment. However, if a notional "social rate of discount," which reflects widespread social attitudes on the importance of remote or postponed future flows of output and consumption, is lower than the market rate of interest, then an argument can be made for discounting future costs and benefits at that lower rate.

Numerous agencies and interests were involved in developing the economic analysis presented in this appendix. As a result, impacts are presented using three different discount rates: 6.875 percent—the rate used in economic analyses by the Corps, 4.75 percent—the rate customarily used by BPA, and 0 percent, which was included on behalf of the tribes represented by CRITFC. The Corps' discount rate is based on the cost of government borrowing. The BPA rate is intended to represent the "real" cost of borrowing money and does not include general inflation. The Corps' rate in contrast does include general inflation. The use of a 0 percent discount rate favored by the CRITFC tribes is based on a desire for permanence of certain assets like fish and wildlife. Benefits associated with projected fish recovery would occur over a long term rather than a short term. These benefits are valued more highly when using a 0 discount rate than the BPA rate of 4.75 percent or the Corps' rate of 6.875 percent. The appropriate use of discount rates has been the subject of some discussion within DREW and the IEAB. While three different discount rates have been used to accommodate a variety of perspectives, the use of these rates has little effect on the ranking of the alternatives.

1.5.3 Subsidies

The effects of subsidies are not addressed in all cases in the following analysis. Subsidies are primarily addressed in those cases where they are known and readily identifiable. This is particularly the case where components of the avoided cost analysis are subsidies. The costs to operate and maintain the navigation locks at the four lower Snake River dams, for example, are not directly transferred to users and are, therefore, considered by some to be subsidies. These costs are identified and presented as a savings or economic benefit in the Implementation and Avoided Costs analysis (Section 3.9). Possible subsidies to other groups, such as farmers, truck and rail services, and recreation users, were not researched as part of this study.

1.5.4 Uncertainty

Uncertainty is inherent in any future-oriented planning effort. The period of analysis for this economic study is 100 years. It is difficult to predict what will happen a few years into the future, let alone 100 years. Considerable uncertainty surrounds any attempt to forecast results 100 years into the future. In general, elements of uncertainty affect everything we do. The Corps' risk and uncertainty guidelines (Corps, 1992; 1995) state that, in the context of water resources planning,

"uncertainty is simply the lack of certainty. It is the reality of inadequate information. When information is imprecise or absent, that is uncertainty." From this perspective, uncertainty is present in all aspects of the Lower Snake River Juvenile Salmon Migration Feasibility Study. The plan formulation, the biology, and the economics all have elements of uncertainty in their analyses. Uncertainty of this type surrounds key study assumptions, methodology, and data collection in all resource areas.

The economic analysis presented in this appendix address the role of uncertainty in two ways. First, each study team was asked to address risk and uncertainty issues in their analyses. Second, an overall risk and uncertainty assessment of the economic and social analyses presented here was conducted as a separate part of the DREW process. The primary source of information for this risk and uncertainty assessment was information provided by the DREW study teams. The results of this assessment and the implications that risk and uncertainty have for the findings of this analysis are presented in Section 8.0 of this appendix.

2. Existing Conditions and Alternatives

This section provides an overview of existing conditions, and discusses the four alternatives considered as part of this feasibility study.

2.1 Existing Conditions

The following section presents summary information on existing conditions. Section 2.2.1 addresses existing socioeconomic conditions in the general project area. A more detailed overview of the existing socioeconomic environment is provided in Section 4.14 of the main FR/EIS text. Section 2.1.3 below provides summary conditions on the four lower Snake River dams and existing fish passage facilities. A more detailed description of these facilities and programs is presented in Chapter 2 of the main FR/EIS text.

2.1.1 Socioeconomic Overview

Land use in the plateau country of Oregon and Washington is predominantly agricultural and open space. Large farms are prevalent with population centers widely dispersed. The eastern portion of the study area, which extends into western Idaho, is largely rural with the primary industries being agriculture and forest products. Local economies in the immediate vicinity of the four lower Snake River dams are largely oriented toward the river system, which provides transportation for agricultural and timber products, water for farmland irrigation, and serves as a source of recreational activity.

Communities located in the vicinity of the lower Snake River would be affected by the natural river alternative. These effects would be felt primarily within communities in the immediate vicinity of the lower Snake River. Effects would also be felt in nearby upland areas that draw water supplies from the river and more distant commodity production areas that rely on the river for transportation. Alternative 4, Dam Breaching, also has the potential to generate indirect economic effects throughout the region. Potential sources of indirect regional economic effects include changes in navigation, recreational activities, commercial fisheries, and power. The regional and social impacts associated with the proposed alternatives are discussed in Sections 6 and 7 of this appendix, respectively. The following sections provide an overview of population and employment in the study region.

2.1.1.1 Population

The majority of the area surrounding the lower Snake River is sparsely populated. Communities range in size from small rural towns with populations less than 200 to cities with populations ranging from 8,000 to almost 50,000. Major population centers in the region include the Tri-Cities (Richland, Kennewick, and Pasco), Walla Walla, the Quad-Cities (Pullman, Moscow, Lewiston, and Clarkston), and Hermiston/Pendleton. Only five communities in the general study area have populations greater than 20,000.

Most of the region experienced fairly rapid rates of population growth in the 1970s. Growth rates were significantly slower in the 1980s with a number of counties experiencing absolute decreases in population. Population has grown more rapidly in the 1990s, with areas offering high quality scenery and recreation opportunities often experiencing particularly rapid growth rates.

Summary population data are presented in Table 2-1 for the states of Washington, Oregon, and Idaho, as well as the three subregions that comprise the 25-county study area identified by the DREW Regional Workgroup (see Figure 1-1 and Section 6).

Table 2-1. Population by State and Subregion, 1970-95

	Total Population				Percent Change		
	1970	**1980**	**1990**	**1995**	**1970-80**	**1980-90**	**1990-95**
Washington	3,413,244	4,132,353	4,866,692	5,430,940	21.1	17.8	11.6
Oregon	2,091,533	2,633,156	2,842,337	3,140,585	25.9	7.9	10.5
Idaho	713,015	944,127	1,006,734	1,163,261	32.4	6.6	15.5
Subregions							
Downriver	172,712	241,361	246,560	278,429	39.7	2.2	12.9
Reservoir	139,055	159,178	162,167	178,739	14.5	1.9	10.2
Upriver	101,292	114,968	114,212	124,951	13.5	-0.7	9.4
Total Study Area	**413,059**	**515,507**	**522,939**	**582,119**	**24.8**	**1.4**	**11.3**

Source: U.S. Census Bureau, 1970, 1980, 1990; State Estimated, 1995

2.1.1.2 Employment

The economy of the Pacific Northwest has undergone substantial change over the past three decades. From 1970 to 1995, the number of jobs in the Pacific Northwest grew at a faster rate than the nation as a whole. The nation saw a 64 percent increase in the absolute number of jobs while employment in the states of Washington, Oregon, and Idaho more than doubled over the same time period. The total number of jobs in both the region and the study area has increased even as employment in historically important job sectors, such as manufacturing, logging, mining, and farming and ranching has declined or remained stagnant. This is also the case with the 25-county lower Snake River study area.

Employment in the study area increased in nearly all sectors between 1970 and 1995 (Table 2-2). Exceptions include the farm and military sectors, both of which experienced an absolute decline in the numbers employed. Employment in service industries has increased significantly. Service industry increases include gains in recreation and tourism, business, education, and management and engineering services. The study area also experienced large gains in the retail trade and state and local government sectors. Growth was also evident in the wholesale trade and the finance, insurance, and real estate sectors.

The majority of towns in the lower Snake River study area are small. Small towns typically have relatively narrow economic bases with fewer industries and fewer firms per industry than larger communities. Almost half of the communities in the region have 20 percent or more of their employment in agriculture, while 68 percent of the communities have 11 percent or more employment in the agricultural sector. This employment includes not only farm proprietors and employees but also farm services. The two other dominant sectors present in the region are state and local government, including school employees, and travel and tourism.

Table 2-2. Employment in the Lower Snake River Study Area, 1970-95

	1970		1995		Change 1970-95	
		%		%		%
Total full- and part-time employment	183,686		318,740		135,054	73.5
Farm employment	29,417	16.0	27,625	8.7	-1,792	-6.01
Nonfarm employment	154,269	84.0	291,115	91.3	136,846	88.7
Ag. serv., forestry, fishing, and other	1,894	1.2	7,721	2.7	5,827	308
Mining	430	0.3	738	0.3	308	71.6
Construction	8,238	5.4	14,715	5.1	6,477	78.6
Manufacturing	24,343	15.9	30,955	10.8	6,612	27.2
Transportation and public utilities	7,745	5.0	11,726	4.1	3,981	51.4
Wholesale trade	4,580	3.0	10,540	3.7	5,960	130
Retail trade	26,732	17.4	53,079	18.6	26,347	98.6
Finance, insurance, and real estate	8,184	5.3	13,290	4.6	5,106	62.4
Services	32,948	21.5	83,390	29.2	50,442	153
Government and government	38,376	25.0	59,740	20.9	21,364	55.7

Source: U.S. Bureau of Economic Analysis, 1999

2.1.2 Authorized Project Purposes

Authorized project uses include power, navigation, recreation, and irrigation. The following sections provide a brief overview of each of these resources. These resources are discussed in more detail in Chapter 4 of the main EIS/FR and Section 3 of this appendix. Fish and wildlife is also an authorized use at all four dams. Fish and wildlife measures are addressed in Section 2.1.3 below.

2.1.2.1 Power

The integrated system of 30 Federal hydroelectric facilities in the Columbia River Basin, on average, accounts for approximately 60 percent of total regional energy and 70 percent of total electrical generating capacity. The four lower Snake River dams account for approximately 12 percent of hydropower sustained peak capacity in the Pacific Northwest and 8 percent of the region's total sustained peak capacity.

When there is a surplus of hydropower, it is an important export product for the region. BPA markets and distributes the power generated by the Corps and the Bureau of Reclamation at the Federal projects in the Columbia River Basin, including power generated by the four dams on the lower Snake River. This power is sold to public and private utilities in the region, utilities outside the region, and some of the region's largest industries. Power lines originate at generators at the dams and extend outward to form key links in the regional transmission grid. The Northwest grid is interconnected with Canada to the north, California to the south, and Utah and other states to the east. Power produced at dams in the Northwest serves customers both locally and thousands of miles away.

2.1.2.2 Navigation

The 465-mile-long Columbia-Snake Inland Waterway formed by the eight dams and locks on the lower Columbia and Snake rivers allows barge transportation from the Pacific Ocean to Lewiston, Idaho, the most inland port. This system is used for commodity shipments from inland areas of the Northwest and as far away as North Dakota. The 140-mile-long stretch of the waterway formed by the four lower Snake River dams extends from the confluence of the lower Snake and Columbia rivers to Lewiston, Idaho. The Corps maintains a navigation channel 250 feet wide and 14 feet deep along this portion of the waterway. This navigation channel accommodates tugs, numerous types of barges, log rafts, and recreational boats and connects the interior Columbia River Basin with deep water ports on the lower Columbia River.

Tonnage using at least a portion of the lower Snake River averaged about 3.8 million tons per year from 1980 through 1990. This average increased slightly to 3.9 million tons per year from 1991 through 1996. Grain shipments made up approximately 75 percent of this tonnage in 1995.

2.1.2.3 Recreation

There are 33 developed recreation sites adjacent to the lower Snake River reservoirs. Facilities at these sites include 28 boat ramps with 59 launch lanes, 5 moorage and marina facilities, 9 campgrounds with approximately 422 individual campsites, and 49 day-use facilities. Most of these sites are located in rural areas removed from population centers. Exceptions include the sites located at Ice Harbor Reservoir, which are close enough to be used by residents of the Tri-Cities, and sites located at Lower Granite Reservoir near the Lewiston-Clarkston area. Several of the larger developed sites were developed by the Corps and are operated by counties or port districts under lease.

Primary recreational activities, including sightseeing, fishing, boating, and water-skiing, occur year-round at most dams and reservoirs in the Columbia River Basin. However, the peak periods of use for all activities occur during the warm, dry summer months. The lower Snake River dams and reservoirs typically receive over 50 percent of average annual reservation from May through August. Approximately 2 million visitor days were recorded at the four dams and reservoirs in 1998. Many of these visitors live in relatively close proximity to the dams and reservoirs.

2.1.2.4 Irrigation

Water is withdrawn from the lower Snake River to support many uses. Irrigated agriculture is the dominant use, followed by municipal and industrial (M&I) water supply, wildlife habitat enhancement, and cattle watering. Nearly all of the lower Snake River water used for agricultural irrigation is withdrawn from the Ice Harbor Reservoir. Private entities have developed the necessary infrastructure to grow irrigated crops adjacent to the reservoir. Approximately 37,000 acres of agricultural land are presently irrigated using water withdrawn from Ice Harbor Reservoir. Cottonwood, which is grown for pulp and paper production, is the largest crop in terms of acreage, accounting for approximately 27 percent of total crop acreage irrigated with water withdrawn from Ice Harbor Reservoir in 1996/1997.

There are eight M&I pump stations along the lower Snake River, all located on Lower Granite Reservoir. Water withdrawn via these stations is used for municipal water system backup, golf course irrigation, industrial process water, and park irrigation. Water withdrawn from the lower Snake River presently irrigates vegetation for ten wildlife Habitat Management Units (HMUs) that

were established to compensate for wildlife habitat lost as a result of inundation by the lower Snake River dams. Cattle watering corridors provide access across government property for cattle to water from the lower Snake River reservoirs.

2.1.3 Facilities and Programs

The four lower Snake River dams—Lower Granite, Little Goose, Lower Monumental, and Ice Harbor—are multi-purpose facilities that provide public benefits in many different areas. The purposes authorized by Congress for the Lower Snake River Project are navigation, hydropower, irrigation, recreation, and fish and wildlife. Project facilities include dams and reservoirs, hydroelectric powerplants and high-voltage transmission lines, navigation channels and locks, juvenile and adult fish passage structures, parks and recreational facilities, lands dedicated to project operations, and areas set aside as wildlife habitat.

All four lower Snake River dams are run-of-river facilities. These dams have limited storage capacity and pass water at nearly the same rate as the water enters each reservoir. Reservoir levels behind these dams vary only a few feet during normal operations. This limited storage is used for hourly regulation of powerhouse discharges to follow daily and weekly demand patterns. This storage is not enough to allow seasonal regulation of streamflows. Other Federal dams on the Columbia River and its tributaries were developed for storage purposes. Storage reservoirs, such as the Dworshak Reservoir on the North Fork of the Clearwater River, are used to store water and adjust the river's natural flow patterns to conform more closely with water uses.

The normal operating ranges and usable storage volumes for the affected hydropower facilities are listed in Table 2-3. While it is physically possible to draw run-of-river reservoirs well below their normal minimum pool levels, the four lower Snake River facilities are not designed to operate below minimum pool levels.

Table 2-3. Characteristics of the Four Lower Snake River Facilities

Facility	Snake River Mile	Facility Ownership	Reservoir Name	Reservoir Capacity (normal operating range, acre-feet)	Reservoir Elevation (normal operating range, msl)
Lower Granite	107.5	Corps	Lower Granite Lake	49,000	733 to 738
Little Goose	70.3	Corps	Lake Bryan	49,000	633 to 638
Lower Monumental	41.6	Corps	Lake Herbert G. West	20,000	537 to 540
Ice Harbor	9.7	Corps	Lake Sacajawea	25,000	437 to 440

msl = mean sea level

2.1.3.1 Adult and Juvenile Fish Facilities

Adult fish passage systems are provided at each of the four dams and include fish ladders, pumped attraction water supplies, and powerhouse fish collection systems. Adult fish passage facilities are operated in accordance with the Corps' Fish Passage Plan (Corps, 1999) as prescribed in the 1995

Biological Opinion and the 1998 Biological Opinion. The operation period is typically from March 1 through December of each year. Juvenile fish bypass facilities were installed at each of the four lower Snake River dams shortly after they were constructed. Current measures for collection and transportation of juvenile fish outmigration are identified in the 1995 Biological Opinion, 1998 Biological Opinion, and the Endangered Species Act (ESA) Section 10 Permit (#895) for the Juvenile Fish Transportation Program (JFTP). The Corps operates the JFTP in cooperation with NMFS and in accordance with the 1995 Biological Opinion and 1998 Biological Opinion.

Juvenile fish are transported under the guidelines of the Fish Passage Plan and the Corps' JFTP. Juvenile fish are not transported at Ice Harbor Dam, but the majority are bypassed directly to the tailrace below the dam. At Lower Granite, Little Goose, and Lower Monumental dams, juvenile fish that go through the bypass systems can be routed either directly back into the river below the dam, or to holding and loading facilities for loading into barges or trucks for transport. Trucks are used for transport when the number of fish collected is 20,000 or fewer per day at Lower Granite.

The transport barges and trucks carry the fish past the remaining projects for release below Bonneville Dam. River water circulates through the barges, allowing the fish to imprint the chemicals and smells of the water during the trip downriver. The adults use this "imprinting" mechanism during upstream migration to guide them to the location where they originated (e.g., spawning area or hatchery).

Collection of juvenile fish generally starts March 25 at Lower Granite Dam and a few days later at Little Goose and Lower Monumental dams. Eight barges are used. Early in the season (typically the second week in April), a barge leaves Lower Granite every other day. As numbers of fish increase, barging is increased to every day. In order to follow the "spread-the-risk" policy described in the 1995 and 1998 Biological Opinions, the current goal is to transport about half of the juvenile Snake River salmon and steelhead. The remainder are either bypassed back to the river, pass through the turbines, or may pass over the spillway if spill occurs.

The Lower Snake River Project facilities are run-of-river and provide little storage of water. Therefore, when reservoirs are full and flows exceed the capacity of the powerhouse or power output needs, water is involuntarily spilled. In contrast, voluntary spills would be those that are not required to pass excess flows downstream (e.g., the powerhouse could pass the flows and there is sufficient power demand). Voluntarily passing water over dam spillways rather than through the powerhouse is an operations approach used to divert juvenile fish from the turbines as they approach a dam.

Dams upstream of Lower Granite can regulate water for flood control, irrigation, and other uses, interrupting the seasonal river flow patterns in downstream areas. Flow augmentation (i.e., increasing river flows above levels that would occur under normal operation by releasing more water from storage reservoirs) can aid migration of juvenile salmon.

In the 1993 and 1995 Biological Opinions, NMFS requested the use of an additional 427,000 acre-feet from upstream storage in Idaho for flow augmentation. This is provided by BOR from the Snake River Basin upstream from Brownlee Dam. Water is secured from BOR's uncontracted reservoir space, water rentals, and by permanent acquisition of reservoir storage space and natural flow rights. The Idaho statute that authorized release of the additional 427,000 acre-feet will expire on January 1, 2000.

The 1995 Biological Opinion discusses the need to pursue the acquisition of additional water after 1998 if necessary to contribute to the survival and recovery of listed fish species. The 1998 Biological Opinion did not change this need. The 1998 Biological Opinion did, however, request that studies be conducted to evaluate an increase in flow above the 1995 amount, perhaps by another one million acre-feet. BOR has conducted the study of the effects of providing one million acre-feet, but no actions have been authorized or implemented.

2.1.3.2 Lower Snake River Fish and Wildlife Compensation Plan

The Lower Snake River Fish and Wildlife Compensation Plan (LSRFWCP) was authorized by the Water Resources Development Act of 1976 to mitigate for fish and wildlife losses caused by construction and operation of the four lower Snake River dams. The LSRFWCP consists of fish hatcheries, satellite fish facilities, a fish laboratory, wildlife habitat areas and development areas, and lands with fishing and hunting access. The facilities and lands of the LSRFWCP are primarily located in the upper, middle, and lower subbasins of the Snake River Drainage, in the states of Washington, Oregon, and Idaho. The remaining facilities and lands are located in the upper Columbia, Yakima, and Mid-Columbia subbasins. Some development is located on existing Federal lands, but the majority is on additionally-acquired lands and easements.

Eleven fish hatcheries were modified or constructed under this plan, along with a number of collection facilities for gathering adults and acclimation ponds for acclimating juveniles to water sources where they would return as adults. These facilities are operated by the state fisheries agencies or the USFWS. Additional recently constructed acclimation facilities are operated by the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation. In addition, the listing of the sockeye salmon resulted in a captive broodstock program that is funded by the BPA. Also, the Nez Perce Tribe has been transporting coho salmon from the lower Columbia River to the Clearwater Basin in an attempt to re-establish runs of these species.

The LSRFWCP also includes 62 HMUs that were developed as mitigation for the loss of habitat associated with the four dams and reservoirs. These HMUs, developed for a wide variety of habitat and species, range in size from less than 1 acre to over 3,000 acres.

2.2 Alternatives Considered

In response to NMFS' 1995 Biological Opinion and the results of the Interim Status Report (Corps 1996), the Corps continued its ongoing process of evaluating various system improvements. These measures are intended to improve the effectiveness of downstream migration by juvenile salmonids and upstream passage of adults. This appendix is a part of the Feasibility Report that analyzes a range of possible actions on the lower Snake River. Other aspects of the Columbia River and upper Snake River operations are addressed under related study processes. These include investigations into drawdown of the reservoir at the John Day Project and studies associated with the Federal relicensing of Idaho Power's Hells Canyon Dam Complex on the Snake River.

The lower Snake River Feasibility Study has been underway since 1995 and numerous alternatives have been identified and assigned combinations of numbers and letters to serve as unique identifiers. However, different study groups involved in the process have all used slightly different numbering or lettering schemes over the last 3 years. The primary alternatives that are being carried forward in this Feasibility Study currently involve four major concepts derived from three major pathways.

The four alternatives that are being evaluated in detail are presented in Table 2-4 along with the naming conventions that have been used by various study groups involved in the study.

Table 2-4. Current Study Alternatives Naming Conventions

Pathway Name	Alternative Name	PATH Number	Corps Number
Existing System	Existing Conditions	A-1	A-1
Major System Improvements	Maximize Transport	A-2	A-2a
Major System Improvements	Major System Improvements	A-2'	A-2c
Natural River Drawdown	Dam Breaching	A-3	A-3a

2.2.1 Existing Conditions

The Existing Conditions alternative consists of continuing the fish passage facilities and project operations that were in place or under development at the time that this Feasibility Study was initiated. The existing programs and plans underway would be continued to meet the authorized purposes of the Lower Snake River Project. Project operations including all ancillary facilities such as fish hatcheries and Habitat Management Units (HMUs) under the Lower Snake River Fish and Wildlife Compensation Plan (LSRFWCP), recreation facilities, power generation, and irrigation would remain the same, unless modified through future actions. Adult and juvenile fish passage facilities would continue to operate. Similarly, work on prototype testing of surface bypass collectors (SBC) at Lower Granite would continue. The Existing Conditions alternative also includes several other planned measures that would affect fish-related expenses. These include:

- New turbine cams that control the turbine blades and wicket gates.
- New turbine runners that may reduce fish stress and mortality.
- Upgrades to Lower Granite Juvenile Fish Facilities.
- Up to seven new fish barges to replace two barges scheduled for retirement.
- Adult fish attraction modifications at fish ladders to ensure adequate water supply is maintained in the event of a pump failure.
- Trash shear boom at Little Goose to capture more debris before it gets into the juvenile fish facilities.
- Modified fish separators to improve fish separation and to reduce stress, delay, and mortality at existing juvenile fish facilities.
- Cylindrical dewatering screens to reduce the amount of water needed for fish collection facilities at Little Goose, Lower Monumental, and Ice Harbor.
- Spillway deflectors/pier extensions at Lower Granite, Little Goose and Lower Monumental to further reduce dissolved gas concentrations.

2.2.2 Maximize Transport

The Maximize Transport alternative would include all of the existing or planned structural and operational configurations from the existing conditions alternative. However, this alternative assumes that the juvenile fishway systems would be operated to maximize fish transport and that voluntary spill would not be used to bypass fish through the spillways (except at Ice Harbor). To accommodate this transport, some measures would be taken to upgrade and improve fish handling facilities.

2.2.3 Major System Improvements

The Major System Improvements alternative would provide additional improvements to those considered under the existing conditions alternative. These improvements would be focused on using SBC facilities in conjunction with extended submerged bar screens (ESBS) and a behavioral guidance system (BGS) located in the turbine intakes. The intent of these facilities is to provide more effective diversion of juvenile fish away from the turbines. Under this alternative the number of fish collected and delivered to upgraded transportation facilities would be maximized as in the maximize transport alternative. A variety of options under this alternative could be implemented, depending upon results of ongoing or future tests of equipment, facilities, and approaches.

2.2.4 Dam Breaching

The Dam Breaching alternative is also called the drawdown alternative in many of the Feasibility Study reports. The term Drawdown, as used by many study groups since late 1996, represents the same alternative as Dam Breaching. There are, however, many types of possible drawdown activities. Therefore, the term dam breaching was created to describe the action behind the alternative. The reservoirs would be evacuated or drawn down by the act of breaching. The dam breaching alternative would involve significant structural modifications at the four lower Snake River dams allowing the reservoirs to be drained resulting in a free-flowing river that would remain unimpounded. Dam breaching would involve removing the earthen embankment sections of the four dams and then developing a channel around the powerhouses, spillways, and navigation locks. With dam breaching, the navigation locks would no longer be operational, and navigation for larger vessels would be curtailed. Some recreation facilities would close while others would be modified and new facilities could be built in the future. The operation and maintenance of hatcheries and HMUs would also change although the extent of change would probably be small and is not known at this time. Dam breaching activities would take at least two full years to complete after an estimated five year period necessary for preparation of a detailed design report and preparation of contracts. Structural modifications would include:

- Modifying intake gates and bulkheads at generator intake bays;
- Removal of generation equipment and dewatering draft tubes and drains;
- Modifications to the powerhouse outlets;
- Placement of sheetpiling or rock materials to stabilize the tailraces;
- Excavation of a river channel around the dam structures with new levee construction;
- Removal of embankment structures;

- Stabilization of highway and railroad bridges and embankments;
- Modification of the water siphons at the Lewiston levees and the adult fish ladder at Lyons Ferry Hatchery;
- Relocation of roads, railroads, and other facilities at the new channel locations;
- Extension of boat ramps and other facility modifications for water wells and other water dependent features.

Other alternatives have been considered by study groups including alternatives that would change upper Snake River flow augmentation levels. These alternative analyses are not presented here as flow augmentation changes are not being carried forward in this study at this time. However, several reports have been completed that evaluated flow augmentation changes and these include the Bureau of Reclamation's Snake River Flow Augmentation Impact Analysis report published in February 1999 (see report on the Corps' website).